SAND2019-1804C

Leveraging Augmented Reality to Enhance the Human-Machine Interface in Space Applications

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ABSTRACT

At Sandia National Laboratories (Sandia), Augmented Reality (AR) is being used in space applications to enhance the human-machine-information interface in two primary areas: data visualization and design. Using AR technology, humans can be immersed in three-dimensional (3D) data. If the correct mapping paradigms are applied, this application of AR has the potential to enable humans to better understand complex, multi-dimensional information. In design, AR technology is being used to reduce design cycle times, production errors, and ultimately costs by providing humans with a 3-D interactive interface to their designs, early and throughout the design cycle.

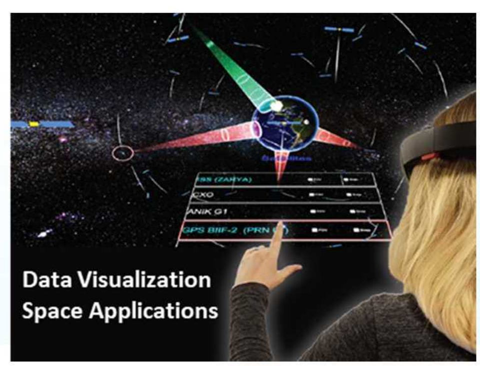
PROJECT DESCRIPTIONS

Sandia is developing a diverse competency in AR across the laboratory, including experts in software design and engineering, immersive user experiences, computer vision, data visualization, and design. Sandia researchers are well-known for possessing a wide range of expertise in a variety of space applications. Thus, Sandia is uniquely qualified to bring together these competencies and bridge the human-machine-information gap. Two on-going projects are researching ways to apply AR to space applications in data visualization and design.

AUGMENTED REALITY FOR DATA VISUALIZATION IN SPACE APPLICATIONS

Advancements in processing capabilities and algorithm design have allowed computer algorithms to calculate solutions to complex problems, but often actions based on these algorithms are still left to a human operator. As the solutions become more complicated it can be harder for a user to interpret and understand results. This project provides a glimpse into how AR may be able to help solve this problem. We believe a 3D environment makes it easier to interpret information that may require multiple two-dimensional displays.

To gauge the effectiveness of AR technology, Sandia has designed an AR space simulation. The space simulation allows the user to interact with a collection of orbiting satellites, view their field of view, and follow a satellite's trajectory, experiencing views from the satellite's position. When experiencing simulations in 3D displays, the user can more easily interpret the environment and grasp concepts, such as distance between orbit regimes, that are hard to represent in two dimensions.



Our application was designed in Unity for use in the Microsoft HoloLens®. When wearing the HoloLens®, a user sees a persistent graphical Earth about the size of a basketball. Around the earth are a variety of satellites orbiting the Earth, each equipped with a field-of-view for a simulated sensor. When the sensor detects an earth-based event, it alerts the user through visual cues, such as a different color field-of-view cone. The user can move about their real world freely because they can see their environment as well as the AR space simulation. The simulation can be anchored to different surfaces in the real world, but once anchored remains fixed as the user moves. The user can

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interact with satellites with their eyes, hands, and voice controls, turning on and off satellite field-of-views and jumping to the satellite's point-of-view.

USING AUGMENTED REALITY TO SPEED SPACE ASSET DESIGN CYCLES

Design is an application that can utilize all aspects of AR technology. There exists a significant gap between flat screen design and realization of full 3D systems, especially when multiple, time-consuming, expensive prototype cycles are often required. AR can help make the concept-to-realization design process more efficient and has the potential to revolutionize current design practices.

At Sandia we are designing and developing a general-purpose AR Design Framework and streamlined workflow. Using this framework, we envision engineers interacting with their designs in a 3D immersive environment and in an exploratory way not possible with flat screens. The framework will provide participants with design interaction mechanisms such as scale, explode, zoom, hide, and cutaway. Participants will interact with their designs via intuitive menu systems, gestures, and voice commands, and receive audio and visual feedback.

Sandia's Advanced AR Design team is developing a prototype framework to evaluate the effectiveness of AR for enhancing the design process. We are integrating cognitive and learning science concepts into the framework to maximize the framework's usability. The team has already created demonstrations of high-fidelity CAD model visualizations using the HoloLens® and Unity in the prototype framework. We have begun to see how the combination of a general-purpose AR framework and high-fidelity model exploration capabilities have the potential to transform the way humans design. From component, to systems, to integration, to maintenance and operations, applying AR to the design process has the promise of reducing errors and design iterations, increasing design confidence, and ultimately reducing costs.

NEXT STEPS

In data visualization, Sandia is working to develop intuitive data mapping paradigms for multi-dimensional space data sets to enable humans to intuitively interpret information when they are immersed in the data through AR. Additional improvements to this work include enhancements to allow visualization of real time data streams. Current demonstrations rely on pre-calculated datasets. The use of real time data may require use of the HoloLens' Wi-Fi capabilities or may require the user to remain tethered to a workstation. Another enhancement we envision is to sync multiple devices together so that users can experience a simulation together. This would enable a group of people to collaboratively engage in a 3D simulation for planning, design, or other discussions.

Next steps for the AR Design framework is to evaluate the completed prototype framework by conducting cognitive studies with Sandia's cognitive science experts and in collaboration with University AR labs. Collaboration discussions are underway with several universities. We plan to evaluate and quantify the framework's effectiveness, ease of use, and the value-added by the AR technology. We anticipate multiple iterations through the development loop (requirements-implementation-evaluation) will be necessary before the framework is deployment ready.

BIOGRAPHIES

Nick Blazier is a member of Sandia's Emergent Systems and Analysis department. He earned his B.S. in Computer Science at the University of Texas at Austin and his M.S. in Computer Science at Carnegie Mellon University. After graduating he joined Sandia where his work focuses on data analysis, visualization, and software engineering.

Dr. Nadine Miner is a member of Sandia's Software Simulation and Analysis department and is the software lead for Sandia's Advanced AR Design team. She has served Sandia for more than 22 years in diverse research areas such as virtual and augmented reality, machine learning, neural networks, software development, and systems engineering. She holds a B.S. in Computer Engineering from the University of New Mexico (UNM), an M.S. in Electrical Engineering from the California Institute of Technology, and Ph.D. in Computer Engineering with Specialization in Virtual Reality from UNM.

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